PATENT SPECIFICATION 905,076

DRAWINGS ATTACHED.

Inventor:—NORMAN GEORGE WORLEY.

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International Classification :—F25h.

COMPLETE SPECIFICATION.

Improvements in or relating to Tubulous Heat Exchangers.

We, BABCOCK & WILCOX LIMITED, a British Company, of Babcock House, 209/225 Euston Road, London, N.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to tubulous heat exchangers of the kind having a bank of staggered tube limbs of tubes each including at least one return bend uniting consecutive tube limbs. The heat exchange effected by a tube operating with a given temperature difference between fluids within and without the tube is affected by the rate of fluid flow over the external surfaces of the tube. For a particular total mass gas flow over a tube bank occupying a given space, a reduction in pitch between the limbs of sinuous tubes of given outer diameter may be expected to give an increased heat transfer, since the number of limbs comprised in the bank and the rate of flow over each limb are increased. The provision of a compact tube bank adapted to give a high rate of heat transfer is particularly desirable when the fluid flowing over the external surfaces of the tube bank is under substantial pressure, since the cost of the heat exchanger is influenced, to a large degree, by the size of the required pressure vessel.

An object of the invention is the provision of a tubulous heat exchanger of the kind in question in which a relatively large number of tube limbs are accommodated in the available space.

The present invention includes a tubulous heat exchanger of the kind having a bank of staggered tube limbs of tubes each including at least one return bend uniting consecutive tube limbs, wherein adjacent tube limbs of alternate tubes are spaced apart by distances less than the external diameters of the tube limbs, tube parts at locations where tubes cross one another being formed to permit the relatively close approach of the said tube limbs.

The invention will now be described, by way of example, with reference to the accompanying, partly diagrammatic drawings, in which:—

Figure 1 is a side elevation of a portion of a bank of staggered tube limbs showing return bends uniting consecutive tube limbs;

Figure 2 is an end elevation corresponding to Figure 1; and

Figure 3 is a sectional plan view of one of the return bends and is taken on the line III—III of Figure 1.

Referring to the drawings, tubes 2, 4 and 6 having respective consecutive tube limbs 12, 13; 14, 15 and 16, 17 are provided with return bends 22, 24 and 26.

The return bend 22 has cross-sections approximating to ellipses, the external minor axes of which are of a length less than the external diameter of the limbs 12, 13 of the tube 2 and the external major axes of which are greater than the said diameter and lie in a plane containing the axes of the tube limbs 12, 13. The end portions 32, 33 of the return bend 22 are suitably contoured to merge into the adjacent end portions 42, 43 which are circular in cross-section and of the same diameter as the tube limbs 12, 13.

The tube limbs 12, 13 are provided with extended heat exchange surfaces in the form of continuous helices, as indicated at 52. In an alternative embodiment of the inven-

tion, the extended heat exchange surfaces are in the form of studs welded to the tube limbs.

During manufacture, a length of tube is bent cold through 180 degrees to the dimensions of the return bend 22, is then heated to a suitable temperature, the end portions 42, 43 positioned properly parallel to one another and terminating in a common plane and the return bend 22 pressed between suitable dies to form the desired elliptical tube configuration. The bend 22 is then united to the tube limbs 12, 13 by suitable welds 62, 63.

The other return bends of the tubes, such as the return bends 24, 26 are of similar form and are manufactured in a similar manner whilst the tube limbs 14, 15 and 16, 17 are similarly provided with extended heat exchange surfaces and are united to the respective return bends by suitable welds.

The other ends (not shown) of the tube limbs are suitably connected into header means or are provided, in a similar manner, with return bends connecting with further limbs.

If it is so desired, a length of tube, portions of which are provided with extended heat exchange surfaces, may be bent to a sinuous form, the bends being made at the portions of the tube unprovided with extended heat exchange surfaces the bends subsequently being heated and pressed between dies to the desired dimensions.

Tubes as hereinbefore described, having return bends of reduced lateral dimension, are assembled as a bank by positioning them, in turn, side-by-side with the limbs in staggered formation and connecting the ends of the tubes into suitable headers (not shown). The bank may be disposed within a pressure vessel (not shown) connected in a closed circuit for the flow of gaseous coolant under pressure in series through a nuclear reactor and the pressure vessel with the tube limbs transverse to a flow path between a pressure vessel inlet and a pressure vessel outlet. Such an arrangement is disclosed in our Complete Specification No. 36520/58 (Serial No. 865,427), based upon Applications Nos. 16218/58, 36520/58 and 36522/58.

The pitch between planes containing the axes of adjacent tubes is determined by the lateral dimension of the return bends and is less than the tube diameter. With such close spacing of the tubes effective contact between the extended heat exchange surfaces 42 and the gases flowing thereover is assured. Furthermore, the closer spacing of the tube limbs allows a greater total heat exchange surface to be accommodated in a given volume.

In an alternative embodiment of the invention, not illustrated, the tube limbs are not provided with extended heat exchange surfaces, a satisfactory heat transfer being effected by virtue of the close spacing of the tubes.

WHAT WE CLAIM IS:—

1. A tubulous heat exchanger of the kind having a bank of staggered tube limbs of tubes each including at least one return bend uniting consecutive tube limbs, wherein adjacent tube limbs of alternate tubes are spaced apart by distances less than the external diameters of the tube limbs, tube parts at locations where tubes cross one another being formed to permit the relatively close approach of the said tube limbs.

2. A tubulous heat exchanger as claimed in Claim 1, wherein the return bends of the tubes transversely of planes containing the axes of the tube limbs of respective tubes have external tube diameters less than the external tube diameter of the tube limbs.

3. A tubulous heat exchanger as claimed in Claim 2, wherein the external tube diameters of the return bends in the said planes are greater than the external tube diameters of the tube limbs.

4. A tubulous heat exchanger as claimed in any preceding claim, wherein the tube limbs are provided externally with extended heat exchange surfaces.

5. A tubulous heat exchanger as claimed in Claim 1, wherein the bank is disposed within a pressure vessel with the tube limbs transverse to a flow path between a pressure vessel inlet and a pressure vessel outlet.

6. A heat exchanger tube having at least one return bend uniting consecutive tube limbs, wherein the external tube diameters of the or each tube bend in a direction normal to the direction in which the limbs extend are substantially less than the external tube diameter of the limbs.

7. A heat exchanger tube as claimed in Claim 6, wherein the external tube diameters of the or each return bend in the direction in which the limbs extend are substantially greater than the external diameter of the limbs.

8. A heat exchanger tube as claimed in Claim 6 or Claim 7, wherein the tube limbs are provided externally with extended heat exchange surfaces in the form of spiral fins.

9. A nuclear reactor power plant including a boiler having a bank of tube limbs as claimed in any one of Claims 1 to 4 disposed within a pressure vessel connected in a closed circuit for the flow of gaseous coolant under pressure in series through a nuclear reactor and the pressure vessel.

10. A tubulous heat exchanger as claimed in Claim 1 arranged and adapted

to operate substantially as hereinbefore described with reference to the accompanying drawings

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

PROVISIONAL SPECIFICATION.

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We, BABCOCK & WILCOX LIMITED, a British Company, of Babcock House, 209/225 Euston Road, London, N.W.1, do hereby declare this invention to be described in the following statement:—

This invention relates to tubulous heat exchangers of the kind having a bank of staggered tube limbs of tubes each including at least one return bend uniting consecutive tube limbs. The heat exchange effected by a tube operating with a given temperature difference between fluids within and without the tube is affected by the rate of fluid flow over the external surfaces of the tube. For a particular total mass gas flow over a tube bank occupying a given space, a reduction in pitch between the limbs of sinuous tubes may be expected to give an increased heat transfer, since the number of limbs comprised in the bank and the rate of flow over each limb are increased. The provision of a compact tube bank adapted to give a high rate of heat transfer is particularly desirable when the fluid flowing over the external surfaces of the tube bank is under substantial pressure, since the cost of the heat exchanger is influenced, to a large degree, by the size of the required pressure vessel.

An object of the invention is the provision of a tubulous heat exchanger of the kind in question in which a relatively large number of tube limbs are accommodated in the available space.

The present invention includes a tubulous heat exchanger of the kind having a bank of staggered tube limbs of tubes each including at least one return bend uniting consecutive tube limbs, wherein adjacent tube limbs of alternate tubes are spaced apart by distances less than the external diameters of the tube limbs, tube parts at locations where tubes cross one another being formed to permit the relatively close approach of the said tube limbs.

In one form of the invention, the return bends of the tubes transversely of planes containing the axes of the tube limbs of respective tubes have external diameters less than the external diameter of the tube limbs.

Suitably, the external diameters of the return bends in the said planes are greater than the external diameters of the tube limbs.

In one embodiment of the invention, the tube limbs have an outer diameter of $1\frac{1}{2}$ inches and the return bends, as seen in cross-section at their central portions, have flat sides, the outer surfaces of which are spaced $1^{5}/_{16}$ inches apart, the sides being united by portions of semi-circular shape. Alternatively the cross-section is of oval form.

The tube limbs are provided externally with extended heat exchange surfaces suitably in the form of a fin or fins having a height of $\frac{1}{2}$ inch. With extended surfaces of such limited radial dimensions, the material of the extended surfaces operates in a highly effective manner and the close spacing of the tube limbs enables the extended surfaces effectively to contact the fluid flowing between the tube limbs notwithstanding the limited radial dimensions of the extended surfaces.

The limbs of each tube are, for example, spaced apart by $4\frac{5}{8}$ inches, whilst adjacent limbs of alternate tubes are spaced apart by $2\frac{5}{8}$ inches. Thus, the planes containing the axes of tube limbs of adjacent tubes are spaced apart by $1^{5}/_{16}$ inches, whilst the planes containing the axes of tube limbs respectively at opposite ends of corresponding return bends of alternate tubes are equidistantly spaced from the planes containing the axes of adjacent tube limbs of the remaining tubes.

The bank is disposed within a pressure vessel with the tube limbs transverse to a flow path between a pressure vessel inlet and a pressure vessel outlet.

It will be appreciated that the invention includes a boiler having a bank of tube limbs, of the nature described above, disposed within a pressure vessel connected in a closed circuit for the flow of gaseous coolant under pressure in series through a nuclear reactor and the pressure vessel.

From the above description will also be understood that the invention includes a heat exchanger tube having at least one return bend uniting consecutive tube limbs, wherein the diameter of the or each tube bend in a direction normal to the direction in which the limbs extend is substantially less than the external diameter of the limbs.

As previously indicated, suitably, the diameter of the or each return bend in the direction in which the limbs extend is substan-

tially greater than the external diameter of the limbs, and advantageously, the tube limbs are provided externally with extended heat exchange surfaces in the form of spiral fins.

During manufacture, a tube may be bent cold to sinuous form, the bends then being heated to suitable temperature, the limbs being positioned properly parallel to one another and the return bends being pressed between suitable dies to form the return bends to the desired configuration.

The invention may be applied to a heat exchanger the limbs of which are unprovided with extended surfaces.

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

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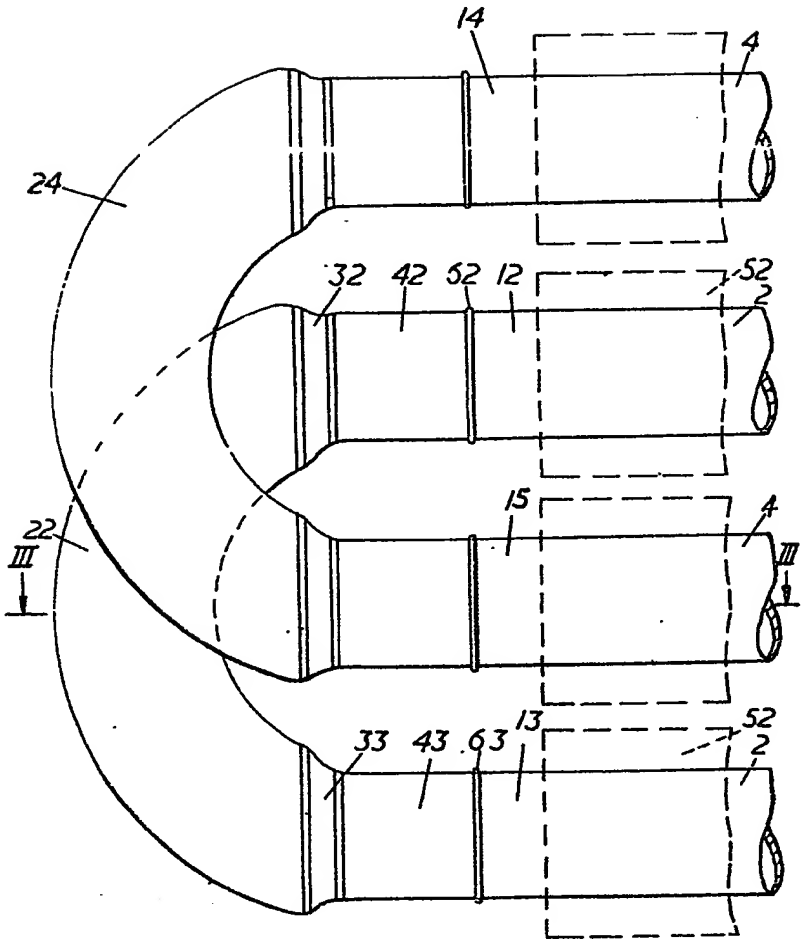
FIG.1.



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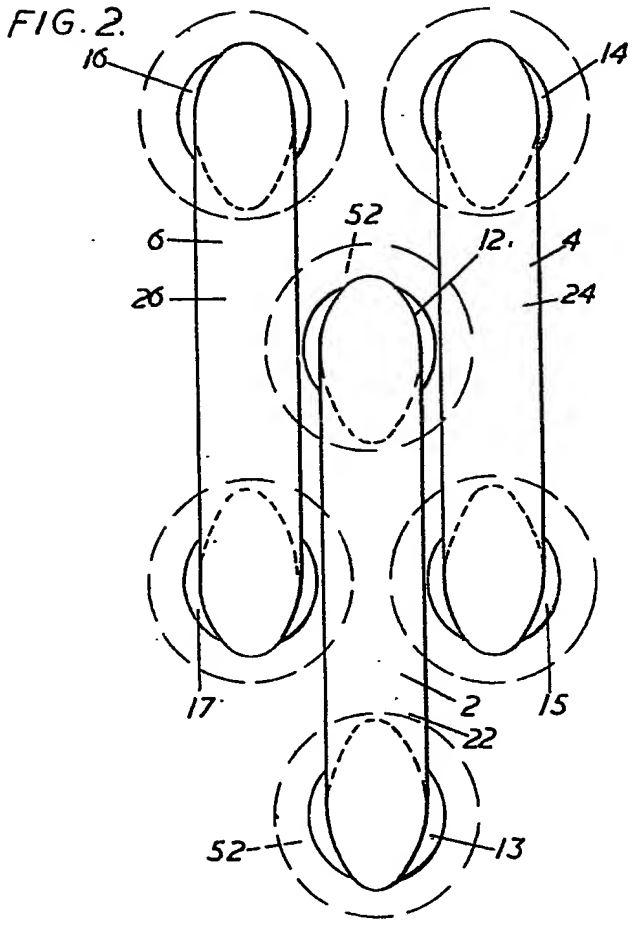
2 SHEETS

FIG. 2.



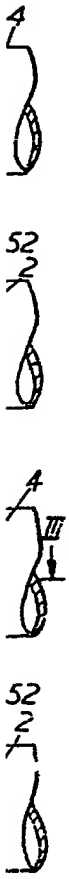
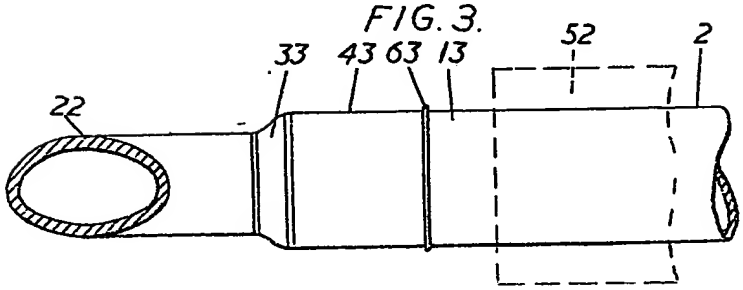


FIG. 3.



905,076 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

FIG.1.

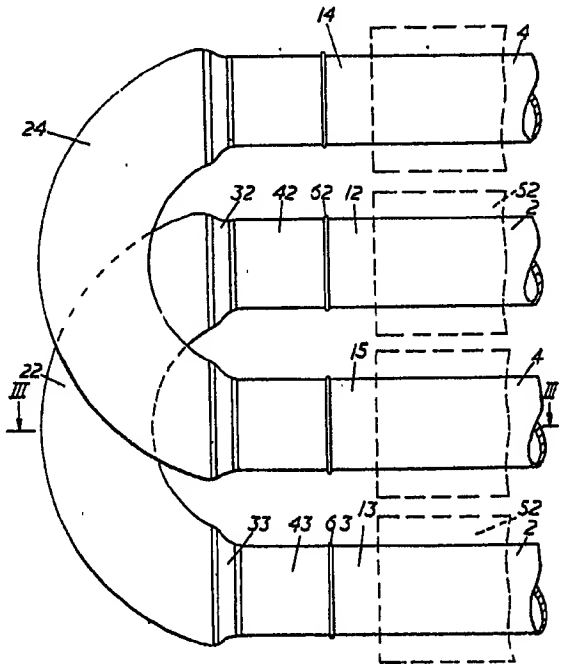


FIG.2.

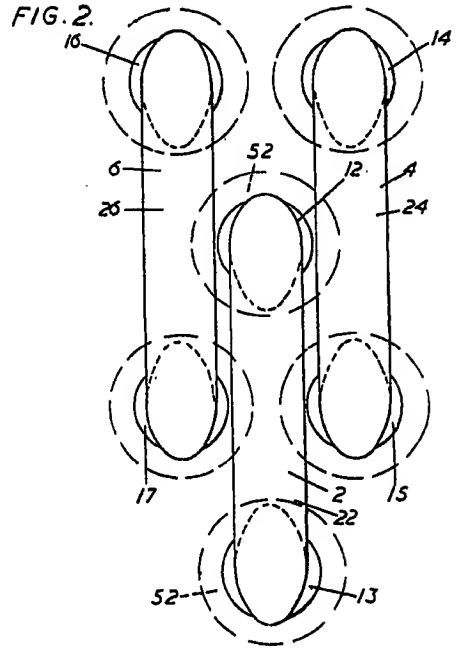


FIG.3.